EFFECT OF EXTREME TEMPERATURES ON 
PICKLEWORM LARVAE AND ADULTS 
(LEPIDOPTERA: PYRALIDAE) 

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ABSTRACT 

Pickleworm, Diaphania nitidalis (Stoll), larvae exposed to –8°C survived much longer within squash fruit than in petri dishes (73.3% survival vs 0% at 1 h). In contrast, survival of larvae exposed to 0°C was similar whether within petri dishes or in fruit. Interior temperatures of shaded squash and cucumber fruits were cooler than air temperature on a summer day, and fruit in direct sunlight were 2–19°C hotter. Considerable mortality (52%) occurred among pickleworm moths exposed to –8°C for 55 min. Survival of moths exposed to 0°C for 21 h was 95%, but fecundity was reduced to almost 0.

RESUMEN 

Larvas de Diaphania nitidalis (Stoll) expuestas a temperaturas de –8°C sobrevivieron mucho más tiempo dentro de frutos de calabaza que dentro de cajas de petri (después de 1 hora, 73.3% sobrevivieron, comparado con 0%). En cambio, a 0°C, la supervivencia dentro de cajas de petri y frutos fue similar. Las temperaturas interiores de frutos sombreados de calabaza y pepino son más bajas que la temperatura del aire durante de un día de verano, y los frutos bajo la luz directa del sol tenían temperaturas de 2 a 19°C más altas. La mortalidad de polillas expuestas a –8°C por 55 minutos fue considerable (52%). La supervivencia de polillas expuestas a 0°C por 21 horas fue de 95%, pero su fecundidad se redujo a casi 0.

The pickleworm, Diaphania nitidalis (Stoll), an important pest of cucurbit vegetables, has an overwintering range in the continental U. S. restricted in most years to southern Florida (Dupree et al. 1955). The life cycle and biology has been described by Dupree et al. (1955), and Reid and Cuthbert (1956). Knowledge of the degree of cold tolerance which this pest possesses would be helpful to population suppression programs such as the sterile male technique by enabling more accurate forecasts of the range and density of pickleworm populations.

Also, there is concern in California that the pickleworm may spread to their vegetable growing regions. Since the climate of many areas in Cali-
fornia is characterized by extreme temperature gradients and maximum temperatures are often much higher than the Southeastern U.S., knowledge of the thermal limits of pickleworms, could enable us to estimate the probability of pickleworm establishment in this important vegetable producing state.

MATERIALS AND METHODS

LOW TEMPERATURE TESTS—Survival of larvae exposed to 0°C and —8°C for varying lengths of time was compared either in petri dishes or within squash fruit. Tests were conducted in refrigerators equipped with Refrigerator Control Units (GCA Precision Scientific®). The freezer compartment of a refrigerator was used for the —8°C tests, and the lower compartment for the 0°C tests. For petri plate tests, 10 early 5th instar larvae were placed in plastic petri dishes (100 x 15 mm) and 4 such dishes were put at the appropriate temperature. Larvae were held at 10°C for 1/2 h before and after exposure. After exposure larvae were placed on pinto bean diet in jelly cups (5 larvae/cup), placed at 27°C, and held to pupation. Exposure time for the —8°C test were 0, 0.17, 0.27, 0.43 and 1.1 h. Exposure times for 0°C were 0, 3, 4, 5, 7, 10, 15, 24, 31 and 45 h. For tests of larvae within fruit, a yellow squash fruit was infested with 5 early 5th instars and allowed to establish for 24 h. At that time 6 infested squash/exposure time were placed at 0°C or —8°C. After exposure, the squash were held for 24 h at 27°C and then dissected. Living larvae were placed on diet and held at 27°C to pupation. Exposure times for the —8°C test were 0, 0.5, 0.75, 1, 1.3, 2, 2.75, 5.25 and 8.5 h and for the 0°C test were 0, 6, 8, 5, 12, 16.5 and 23 h.

To monitor the internal fruit temperatures that confront pickleworms, 2 squash fruits were placed at 0°C or —8°C and their internal temperature measured with copper-constantin thermocouples attached to a CRS® digital recorder (Campbell Scientific, Inc.) until their internal temperature reached air temperature. The fruit held at 0°C weighed 196 g and the one at —8°C weighed 335 g.

Pickleworm adults were also exposed to 0°C and —8°C for varying lengths of time. For each exposure time, three 12 x 5 x 8 cm plastic crispers containing 8 males and 8 females were placed at the appropriate temperature. Moths were held at 10°C for 0.5 h before and after exposure. Survivors from each crisper were placed in separate oviposition cages (Robinson et al. 1979). Counts of survivors were taken after 24 h in the —8°C test and at 24, 48, and 72 h for the 0°C test. After 72 h, cucumber seedlings were placed into the cages of moths exposed to 0°C and the eggs deposited counted the next day. Exposure times for the —8°C test were 0, 0.5, 0.92 and 1.5 h. Exposure times for the 0°C test were 0, 2, 4, 7, 12 and 21 h. Regression analysis of the data was performed with the Textronix Plot 50® Statistics Program Library.

HIGH TEMPERATURE TESTS Fifth instar larvae within cucumber fruit were exposed to various high temperatures (27°C, 30°C, 32°C, 34°C, 36°C, and 38°C) to determine the threshold temperature at which they would fail to pupate. Ten larvae were allowed to burrow into a cucumber held in a covered 19 x 14 x 9 cm plastic crisper. The fruit rested on 2 cm thick pads of
fiberglass insulation which served as a pupation medium. Crispers were checked daily for dead larvae or pupae.

The internal temperatures of shaded and unshaded squash and cucumber were recorded during a sunny summer day (VII-1-80) on 2 adjacent plots of bare ground. Shaded fruits were placed under 24 cm² tents of aluminum sheet metal. Temperatures were recorded by thermocouples attached to a CRS® temperature recorder. Air temperature was recorded by a thermocouple in a weather shelter. Treatment levels were: (1) Cucumber vs. squash, (2) Shaded vs direct sunlight, (3) Large (≥ 200 g) fruit vs small (< 100 g) fruit. Third level treatments were replicated 3 times.

RESULTS AND DISCUSSION

Larvae exposed to 0°C in petri dishes had high survival beyond 24 h, but at —8°C few larvae survived to pupate after 0.5 h exposure (Fig. 1). Survival of larvae within squash at 0°C differed little from those unprotected; however, survival of larvae exposed to —8°C within squash was much higher than that of unprotected larvae (Fig. 1). The internal temperature of the squash fruit placed at 0°C declined rapidly from room temperature to 0°C in ca. 3 h. The temperature of squash placed at —8°C also declined rapidly to 0°C, but because of the latent heat given off by the freezing process, the temperature remained at 0°C for 5.5 h. When the fruit was completely frozen the temperature resumed a rapid drop to —8°C. Thus, even though the air temperature might drop below 0°C for several hours during a cold spell in an overwintering area, pickleworms within fruit would probably experience only 0°C, which they can apparently survive.

Data for the —8°C exposures indicate that considerable mortality occurs among moths exposed to this temperature for over an hour (e.g. 52% were dead after 24 h at 0.92 min exposure and 100% mortality at 90 min exposure). However, moths could apparently tolerate 0°C for several hours with no adverse effects. Only 4% of the moths were dead after 24 h when exposed to 0°C for 4 h or 7 h. At 21 h, the longest exposure, mortality of the moths was 35.4%. A linear relationship (r² = 0.96) existed between time exposed to 0°C and number of eggs laid, described by Y = 68.3 + (—5.9) X. The number of eggs laid declined from 55.0 eggs/female at 2 h exposure to 0°C to only 0.3 eggs/female at 21 h exposure. Therefore, a severe cold spell with temperatures near —8°C for several hours could decimate a local overwintering population of moths. Most moths would survive a less severe cold spell with temperatures near 0°C, but if extended, the egg laying capacity of the population might be considerably diminished. Elsey (1980) found that approximately 90% of pickleworm pupae died at 4 h exposure to 7°C, and the results of this study indicate that all moths died after 90 min exposure to —8°C. Therefore, the hardest overwintering stage would appear to be large larvae within fruit, since 40% could survive 5.25 h at —8°C. During a visit to Homestead, FL in late Jan 1979 by the author, the only pickleworms observed were large larvae in fruit that were laying in post-harvest fields.

Table 1 shows the divergence from air temperature of the internal temperatures of shaded and unshaded squash and cucumber fruits during the day. Shaded fruits of both squash and cucumber were usually cooler than air temperature. Fruits exposed to direct sunlight were 2 to 10 degrees
Fig. 1. Survival of pickleworm larvae in petri dishes and within squash fruit at 0°C (a) and −8°C (b).
<table>
<thead>
<tr>
<th>Time</th>
<th>Air temp °C</th>
<th>Squash</th>
<th>Cucumber</th>
<th>Squash</th>
<th>Cucumber</th>
<th>Unshaded Squash</th>
<th>Unshaded Cucumber</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Shed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 AM</td>
<td>24.5</td>
<td>-1.1</td>
<td>-1.8</td>
<td>-1.2</td>
<td>-1.8</td>
<td>-1.7</td>
<td>-1.9</td>
</tr>
<tr>
<td>10 AM</td>
<td>30.1</td>
<td>-3.7</td>
<td>-2.8</td>
<td>-2.6</td>
<td>-2.4</td>
<td>-0.2</td>
<td>-0.6</td>
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<tr>
<td>12 NOON</td>
<td>33.5</td>
<td>-2.2</td>
<td>-2.7</td>
<td>-0.5</td>
<td>-1.6</td>
<td>+4.6</td>
<td>+4.4</td>
</tr>
<tr>
<td>2 PM</td>
<td>35.3</td>
<td>-1.4</td>
<td>-5.4</td>
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<td>-2.6</td>
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<td>4 PM</td>
<td>35.4</td>
<td>-2.1</td>
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<tr>
<td>6 PM</td>
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<td>+1.7</td>
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<td>0</td>
<td>-0.6</td>
<td>+1.6</td>
<td>+0.4</td>
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Table 1. Internal heat differences from air temperature for shaded and unshaded cucumbers and squash on a sunny day VII-1-30.
hotter than air temperature and 3 to 13 degrees hotter than shaded fruit during the hottest part of the day. Cucumbers in direct sunlight became hotter than squash, probably because the darker color of cucumbers enabled them to absorb more solar radiation.

At constant temperatures above 32°C, survival of larvae within cucumbers declined drastically (Table 2). A comparison with 2 other tropical-subtropical lepidopterous pests shows that pickleworm larvae are more susceptible to high temperatures. When reared through the entire larval stage, fall armyworm larval survival was 27% at 25°C (Barfield et al. 1978) and pink bollworm survival was 33% when reared at 37.7°C (Henneberry et al. 1977). Under field conditions, adaptive behavior of larvae may ameliorate the effects of high temperature. I observed that larvae held at 32°C in cucumbers tended to leave them in an apparent escape response. Conversely, the higher ambient temperature of a fruit exposed to the sun can be of advantage to overwintering larvae during the sunny conditions usually associated with cold air masses in the southeast U. S.

Elsey (1980) found that temperatures of 32°C or higher decreased normal pickleworm adult emergence, fecundity, and longevity. Fye (1972) reported decreased fecundity of 6 lepidopterous pests at temperatures above 30°C. It is tempting to conclude that temperatures in excess of 32°C may lead to sterility or reduced fecundity (Elsey, unpublished data) in populations of pickleworms; however, the behavioral and physiological mechanisms that may moderate the effects of heat in a complex environment are so little known that the actual impact of heat on a population of moths can only be guessed.

Whether self sustaining populations of pickleworms can develop in California is difficult to answer, considering the extremely heterogenous climate and geography of the state. Southern desert areas, such as the Imperial Valley, are probably too hot and dry in the summer and too cold in the winter. However, vegetable growing areas such as San Luis Obispo Co. with mild summers and winters, could support year-round populations of pickleworms, assuming other elements of the life system were favorable.

References Cited


Table 2. Survival of pickleworm larvae within cucumber fruit exposed to high temperatures.

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>% surviving to pupate ± SD</th>
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<tr>
<td>27</td>
<td>82.5 ± 14.9</td>
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<tr>
<td>30</td>
<td>81.3 ± 15.5</td>
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<tr>
<td>32</td>
<td>80.0 ± 15.1</td>
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<td>34</td>
<td>1.3 ± 3.5</td>
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EFFECTS OF A NEW CARBAMATE INSECTICIDE, LARVIN (UC-51762), ON SOME NONTARGET AQUATIC INVERTEBRATES

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ABSTRACT

The effects of a new carbamate (thiodicarb) insecticide, UC-51762 or Larvin (O-[N-[[N’-(methylthiolideneiminoxy)carbonyl]-N’-methylaminosulfenyl][N-methylcarbamoyl]]-S-methylacetothiohydroximate), on some non-target aquatic invertebrates in experimental and sewage ponds were studied. The insecticide at 0.25, 0.5, and 1.0 kg AI/ha (i.e. 0.055, 0.11, and 0.22 ppm, respectively) in experimental ponds affected populations of Rotifera, Cyclops spp., Daphnia sp., Ostracoda, Chaoborus sp., Baetis sp., coleopteran larvae and chironomid larvae. In a sewage pond, at 1.0 kg AI/ha (0.085 ppm), Cyclops sp., Ostracoda, Hyalella azteca (Saussure), and chironomid larvae were affected. The adverse effects of the carbamate insecticide on the invertebrates in both types of habitats were moderate and generally of a short duration.

RESUMEN

Se estudiaron los efectos de un nuevo carbamato, UC-51762, o Larvin, sobre unos invertebrados acuáticos, los cuales no son objetos de control químico, en charcas experimentales y de aguas negras. El insecticida aplicado a 0.25, 0.5 y 1.0 Kg. AI/ha (i.e., 0.055, 0.11 y 0.22 ppm, respectivamente) en las charcas experimentales afecto las poblaciones de Rotifera, Cyclops spp., Daphnia sp., Ostracoda, Chaoborus sp. Baetis sp. y larvas de coleópteros y de chironomidos. En charcas de aguas negras Cyclops sp., Ostracoda, Hyalella azteca (Saussure), y larvas de chironomidos fueron afectados por el insecticida a 1.0 Kg. AI/ha (0.085 ppm). Los efectos adversos del insecticida carbamato sobre los invertebrados en ambas clases de hábitat fueron moderados y generalmente de una duración corta.

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